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Moving Map Support for the BQM-147A EXDRONE Unmanned Aerial Vehicle

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The U.S. Marine Corps and the U.S. Army both deploy the BQM-147A EXDRONE Unmanned Aerial Vehicle to provide commanders with unmanned air reconnaissance, surveillance, and target acquisition and battle damage assessment capabilities using electro-optical devices. The EXDRONE also has the capability to carry electronic warfare and nuclear, biological, and chemical detection payloads. The Naval Research Laboratory (NRL) has developed a prototype moving map display for the EXDRONE using an IBM-compatible notebook computer and standard Defense Mapping Agency digital maps. This prototype system has proved successful during training exercises at the Marine Corps Air Ground Combat Center at Twentynine Palms, CA. NRL has proposed further enhancements to the system to improve operator feedback and minimize operator intervention. This system is expected to be easily adaptable for use in tracking other vehicles.

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INTRODUCTION

The U.S. Marine Corps and the U.S. Army both deploy the BQM-147A EXDRONE Unmanned Aerial Vehicle to provide commanders with unmanned air reconnaissance, surveillance, and target acquisition and battle damage assessment capabilities using electro-optical devices. The EXDRONE also has the capability to carry electronic warfare and nuclear, biological, and chemical detection payloads. The Naval Research Laboratory (NRL) has developed a prototype moving map display for the EXDRONE using an IBM-compatible notebook computer and standard Defense Mapping Agency (DMA) digital maps. This prototype system has proved successful during training exercises at the Marine Corps Air Ground Combat Center (MCAGCC) at Twentynine Palms, CA. Further development is planned at NRL and a second prototype is scheduled for field tests in FY95.

BACKGROUND

The BQM-147A EXDRONE UAV is used for reconnaissance by both the U.S. Marine Corps and the U.S. Army. The EXDRONE system consists of the aircraft, payload, launch system, and ground control station (GCS). The entire system can be deployed in a single high-mobility multi-purpose wheeled vehicle.

The EXDRONE aircraft is propeller-driven and of the "flying wing" design. It is powered by a single one-cylinder, two-cycle, air-cooled gasoline engine, has a wingspan of about 2.5 m (8 ft), and weighs about 39 kg (85 lbs). The aircraft has a top speed of 160 kph and a range of 30 km.

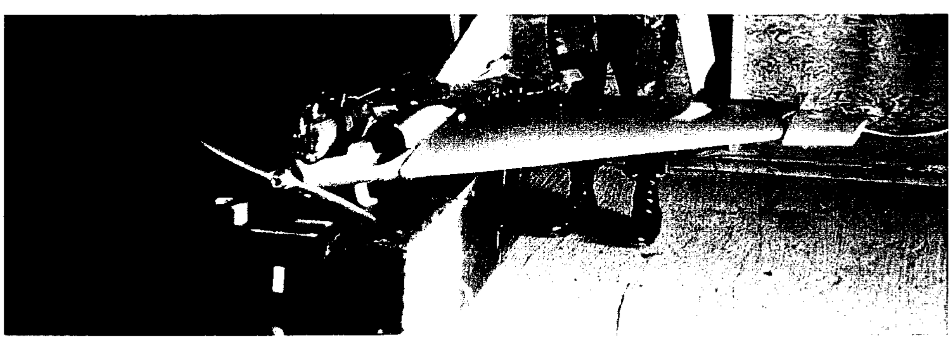

Fig. 1 — EXDRONE unmanned aerial vehicle

It can be operated in temperature ranges from –30° to 40°C (–25° to 104°F) and the service ceiling is 3000 m (10,000 ft). The aircraft is equipped with Global Positioning System (GPS) and can be programmed to fly up to five waypoints automatically, or can be flown manually by a pilot on the ground. The GPS position and other aircraft parameters (altitude, heading, tachometer reading, etc.) are transmitted to the GCS in real time.

The EXDRONE payload normally consists of a down-looking color zoom camera with a pan and tilt capability in development. The aircraft also carries a forward-looking color camera and has been tested with image intensifiers and forward-looking infrared (FLIR) sensors. The video signal is transmitted back to the GCS in real time.

The EXDRONE can be launched from a trailerable pneumatic launcher in winds up to 30 kt. Recovery is made by parachute.

The GCS is a man-packable unit (11 kg; 25 lbs) with a range of 30 km. The GCS can be powered by external batteries, tow vehicle power, or a 1.5-kW generator. The GCS provides color video from both payload cameras, and an alphanumeric readout of aircraft location, altitude, heading, etc. In normal operations, two GCS units are used, one manned by the pilot and the other

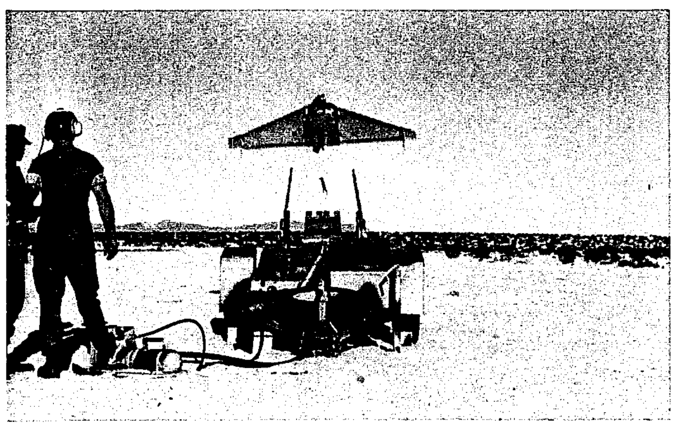

Fig. 2 — EXDRONE launch

Fig. 3 — EXDRONE pneumatic launcher

by the navigator. The navigator uses the GCS readout of northings and eastings to locate the aircraft on a paper map.

In April 1994, the U.S. Marine Corps tasked NRL to develop a prototype moving map display to be field tested with the EXDRONE in May 1994. From 16 May to 20 May 1994, tests of the NRL software were conducted at the Marine Corps Air Ground Combat Center in Twentynine Palms, CA.

EXDRONE MOVING MAP CONFIGURATION

The EXDRONE moving map display is based on software developed for the MC&G Utility Software Environment (MUSE). MUSE is a joint service project sponsored by the DMA and includes a platform-independent mapping toolkit for the display of standard DMA digital products.

Existing MUSE software was enhanced to include an "automate" function which allows automatic updates of map information at regular time intervals. In addition, software was developed to read telemetry information from the GCS and pass this information to the MUSE software.

The EXDRONE hardware consists of an IBM-compatible active matrix color notebook computer and an external modem which is connected to the GCS.

EXDRONE TELEMETRY DATA

Several aircraft parameters are sent to the GCS via telemetry approximately every second. The data stream consists of two messages, each preceded by two sync bytes and followed by a two-byte checksum. The first message includes data about vehicle performance, while the second message includes navigational information.

Telemetry information available at the GCS includes

- air vehicle coordinates,
- air vehicle magnetic heading,
- altitude,
- autopilot elapsed time,
- uplink received signal strength indicator,
- downlink signal strength,
- autopilot mode,
- bearing to next waypoint,
- number of next waypoint,
- GPS status,
- GPS ground track heading, and
- range to next waypoint.

SYSTEM HARDWARE CONFIGURATION

The prototype moving map display hardware consists of an IBM-compatible notebook computer and an FSK/RS-232 modem. The computer is an Intel 486, 66-MHz system with 8 Mbytes of memory, 340 Mbytes of disk storage, a built-in trackball, and an active matrix color display. The system may be powered by 110 VAC or can be run for approximately 2 hours on internal batteries.

The FSK/RS-232 modem is built by Aerocon, Inc., and may be powered by 110 VAC or external 9- or 12-V batteries. The modem uses a 4-pin Canon connector to connect to the GCS "C/S" connector, and a DB9 9-pin serial cable to connect to the computer's COM1 serial port.

MAP DISPLAY/GCS INTERFACE

Information from the aircraft is encoded on an audio subcarrier of the telemetry signal using frequency shift keying. The telemetry is encoded at 1200 baud using 8 data bits, 1 stop bit, and no parity. The moving map display requires an additional modem for conversion from FSK to RS-232 for input to the notebook computer. The modem can be powered by the same power source as the GCS, or by a standard 9-V battery for short periods.

The modem is connected to the GCS using a 4-pin Canon connector. A DB-9 connector is used to connect the modem to the notebook computer. Various power connectors are used based on the available power source.

SYSTEM SOFTWARE CONFIGURATION

The prototype moving map system consists of two separate software programs running under Microsoft Windows, Version 3.1, and MS-DOS Version 6.2. All software is written using Borland C and the eXtensible Virtual Toolkit. A data-collection program reads telemetry data from the COM1 serial port once each second and writes the data to a file on disk. Once started, this program requires no further interaction from the operator. The program is hardware-specific, and will run only on IBM-compatible systems under MS-DOS. A second program displays the background maps, reads the telemetry data from disk, and plots the current vehicle position on the screen at 2.5-s intervals. The operator may scroll the map image on the screen or choose different map areas. This software is not platform specific and will run on IBM PCs, Apple Macintosh, and Sun/Motif systems.

DIGITAL MAP DATA

The map data used by the display program is derived from the DMA Tactical Pilotage Chart (TPC) at 1:500,000 scale and the terrain line maps (TLM) at 1:50,000 scale distributed on CD-ROM by DMA. A single TPC (the "default" map) covers the entire operating area, and numerous TLMs, each 20 × 20 km, cover the area at 1:50,000 scale with overlaps between maps. When the program is started, the default map is displayed. This map includes an overlay which describes the boundaries of the TLM submaps. The TLMs contain no overlays and are downsampled such that 1 km is equal to approximately 1 cm on the screen display. The TPC and TLM maps for the MCAGCC at Twentynine Palms, CA, require about 80 Mbytes of disk space.

SYSTEM OPERATION

The FSK/RS-232 modem is connected to the GCS C/S connector and to the notebook computer's COM1 port. The modem may be connected to 110 VAC power using an external power supply or to external batteries. The computer may be run from 110 VAC power or from the internal batteries. No further connections are required, and the GCS hardware and software requires no modification.

To start the moving map display, MS Windows must be running. The data collection program may then be started by double-clicking on the "EXDRONE" icon, then clicking on the "START" button. If the GCS is operational, the EXDRONE window will show a valid northing and easting and a magenta "queue size" message will appear. No further user interaction is required for this program and it may be iconified.

To start the map display program, the user must double-click on the "FUSION" icon. The program will then display a TPC map of the operating area, with the Exdrone position displayed in the Fusion window title bar. The Exdrone position will be displayed on the TPC map as a red cross if the Exdrone is within the operating area. The TPC map may be scrolled using the scroll bars.

The TPC map includes blue two-digit numbers at regular intervals. These numbers indicate the center of a 1:50,000 TLM with the ".map" appended as the file name (for example, the map

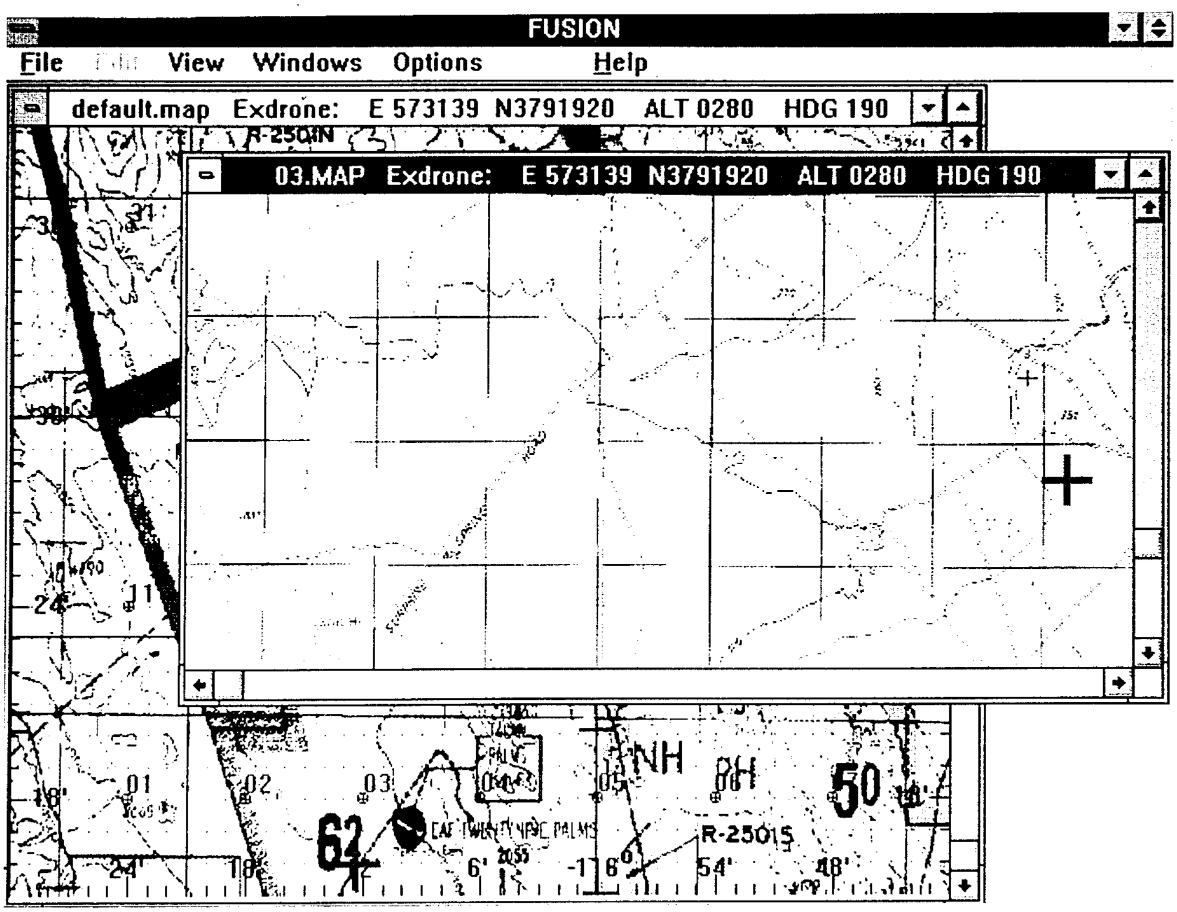

Fig. 4 — EXDRONE moving map display

centered at the blue "03" would be 03.map). These maps may be displayed by choosing "FILE OPEN" from the menu bar, then choosing the appropriate map. It may be necessary to use the scroll bars to locate the Exdrone position, since the maps are twice as big as the screen display area.

As the aircraft flies into another TLM map area, the on-screen map may be iconified if the aircraft is expected to return to the area. This will reduce the time necessary to redisplay the map later. Due to memory limitations, only four maps may be displayed and/or iconified at any time. If necessary, the map window may be closed and the map later reopened using the "FILE OPEN" menu item.

The moving map software will continuously track the Exdrone, with the vehicle heading and altitude updated every 2.5 s in the window title bar, and the vehicle position updated on the map every 12 s. The 12-s update rate is due to software limitations aboard the Exdrone, which only provides position updates to the GCS every 12 s.

To stop the moving map system, the operator must choose "FILE EXIT" in the Fusion window, followed by "FILE EXIT" in the Exdrone window.

SUMMARY

A low-cost prototype moving map display for the BQM-147A EXDRONE Remotely Piloted Vehicle has been developed by NRL. This prototype has been tested in the field with Army and Marine Corps units and has proven successful. Further enhancements to the system to improve operator feedback and minimize operator intervention are being planned. This system is expected to be easily adaptable for use in tracking other vehicles.

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BIBLIOGRAPHY

User's Guide, MUSE Version 1.0, Defense Mapping Agency, June 1994.

Operations Manual, BQM-147A EXDRONE Remotely Piloted Vehicle (EXDRONE RPV) System, Commandant of the Marine Corps, April 1994.